Discussion Papers In Economics And Business

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Adoption—Theory and Evidence from Vietnam

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October 2015

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Productivity, Capital Intensity and ISO14001 Adoption—Theory and Evidence from Vietnam

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[2015/10]

Abstract

The determinants of ISO14001 adoption have been considered to fall into two categories: the external pressure from environment-oriented stakeholders or customers; the internal need due to expected future benefits. In this paper we take a step further to elaborate on the mechanism of firms' adoption by investigating the interrelationship among firms' productivity, capital intensity and the decision-making of the adoption. Applying a general equilibrium model, we show that under optimal condition, highly productive firms can benefit more from the adoption. In the meantime technology advancement potentially drives up the capital intensity of the firms, and this factor will positively affect firms' incentive of adoption as well. The empirical practice using the firm-level data in Vietnam verifies our predictions with robustness. In addition, we find that the phenomenon outlined above becomes even more obvious in the manufacturing sectors.

Keywords: productivity, capital intensity, ISO14001, Vietnam, environmental protection.

JEL Classification Numbers: D22, F21, F64, Q56.

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1 Introduction

Due to a rising awareness of environmental protection, there has been an increasing literature to study the determinants of ISO14001, a voluntary environmental management program. Research on external factors indicates that pressure from environmentally conscious customers plays a important in firms' adoption of ISO14001 (Nishitani, 2010). Whereas internal determinants such as firm size, the status of having quality management system and market scope of the industry that the firm belongs to are shown to be important factors (Arimura et al., 2008, 2011; Nakamura et al., 2001; Welch et al., 2002).

Nevertheless, all these studies try to locate the determinants of ISO14001 adoption from a relatively objective perspective. From the point view of the firms themselves, what are the systematic incentives for them to spend substantial cost on adopting this standard even if it is voluntary rather than compulsory? What is the starting point for firms to think about the adoption originally? It is natural to assume that when firms are technologically struggling, usually they can't afford to spend extra money on self-regulated environmental activities. In other words, firms with technology advancement will have better chance to engage in environmental protection activities, In fact, recent studies by Levinson (2009), Shapiro and Walker (2015) have shown a negative relationship between firms' productivity (technology) and pollution intensity in US.

Following this logic, we pay a special attention to the relationship between firms' initial technology level and their participation rate in the voluntary environmental program. Drawn from the firm-level survey data in Vietnam, Figure-1 indicates the difference in total factor productivity (TFP) for different groups of firms prior to ISO14001 adoption. As we can see, the average TFP for ISO14001 adopted firms is higher than that for non ISO14001 adopted ones. Consistent with the previous studies, it occurs to us that the heterogeneity in TFP tends to be an important decisive factor for firms to adopt the standard.

Figure-1 is inserted here

On the other hand, factor endowment hypothesis, brought forward by Copeland and Taylor (2004), presents as another interesting theory to describe the relationship between factor intensity and pollution behavior in the context of international trade[1]. However, research on the direct relationship between a firm's factor intensity (we focus on capital intensity in this paper) and its decision to engage in environmental protection, is very scare.

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[1]The hypothesis argues that when trade liberalizes, countries that are abundant in factors used in clean industries will grow cleaner.

Some of the existing studies mention the positive correlation between capital intensity and pollution (Mani and Wheeler 1997), but none has taken a step further to investigate how capital intensity matters for firms' commitment to environmental protection. Our interest thus lies in the question that under the same pollution level, will capital-intensive firms have higher/lower incentive to participate in environmental protection program voluntarily?

To answer the above questions and make clear the interrelationship among firms' productivity, capital intensity and their adoption of ISO14001, we employ an analytical general equilibrium model. Driven by the stylized fact as in Figure-1, we put additional assumption on firms' heterogeneity, which is modeled by their differential productivity. Each firm draws a unique productivity level, which leads firms to differ in their equilibrium price markup and expected total profits. Meanwhile the equilibrium productivity level will affect the capital intensity of a firm[2], and ultimately affects the firm's decision of adopting ISO14001. We then take the model to the data. Relying upon the detailed firm-level data taken from annual enterprise survey in General Statistics Office in Vietnam, we find that productive firms and capital-intensive firms have higher incentive to adopt ISO14001, which is consistent with the predictions from our theoretical model. Other control variables such as firm size and foreign capital share also play significant role in shaping the decision on ISO14001 adoption. In the subgroup estimation, we find that the influence of productivity and capital intensity becomes stronger for manufacturing firms to adopt ISO14001 than for non manufacturing ones. Whereas foreign capital share turns out to be insignificant for non manufacturing firms to make the decision.

Our paper contributes to the existing literature in several ways. First, the theoretical model weaves together the factors from industrial organization and environmental economics, using the framework of international trade literature. To our best knowledge, it is the pioneer one of its kind. Second, we concentratedly analyze the role of the productivity and capital intensity in shaping a firm's decision-making of ISO14001 adoption. This is one of the few studies that attempt to clarify the mechanism behind firms' participation in a voluntary environmental program. Third, by far there has been no research to study the determinants of ISO14001 in the context of Vietnam. We aim to fill in this blank by making use of the firm-level information in Vietnam.

The paper is organized as follows: in the next section we talk briefly about the ISO14001 and why it is important to be concerned about environmental protection in the context of Vietnam. Literature review comes after. In section 4 we apply a theoretical model to show how firms' decisions are made. In section 5 we describe the data and estimation strategy, followed by robustness check and findings. The final section concludes.

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[2]Or the capital intensity can be modeled as exogenous, depending on the functional assumption.

2 Background

2.1 About ISO14001

The International Organization for Standardization (ISO) was founded in 1946, which has 162 members[3] by far, each representing a country. It is the most prominent developer of standards in the world. In 1980s, ISO introduced ISO9000 standards for quality manufacturing practices. Building on this system, ISO set up ISO14001 environmental standards in 1996[4]. According to the definition by ISO, this standard enables firms to adopt the policy following the legal requirements and provides them with update environmental information. In other words, it forces the organizations to raise self-awareness of maintaining a healthy environment and assure themselves of conformity with their stated policies. The benefits of ISO14001 include, but not limited to: reduced cost of waste management and distribution; savings in consumption of energy and materials; improved corporate image among regulators, customers and the public (ISO Homepage). Despite all the merits, ISO14001 does not come for free. Due to complicated application procedure, the standard practice is to entrust an ISO-accredited third party with all the evaluation and paperworks. According to Jiang and Bansal (2003), the initial consulting fee usually ranges from 24,000 to 128,000 USD. The additional spending will include training expenses, application fee, auditing fee, etc. Though the total cost varies from country to country, it can become quite a burden, especially for small and medium sized firms. Thus firms need to weigh the benefits against the expenditure discreetly before making the decision to apply.

2.2 Why is the issue important in Vietnam?

The pollution level in Vietnam is highly proportionate to its economic growth that depends on the fast industrialization. From Figure 2, we can see that the total pollution in Vietnam has risen by nearly 150 percent over five years. Decomposing the contents, we find that most of the increase comes from air and solid waste, most of the discharge comes from industrial activities. Take air pollution, for instance, nearly half of Nitrogen dioxide (NO_2) emission is due to industrial development. When it comes to Sulfur dioxide (SO_2), manufacturing industry turns out to be the major source (Vietnam: Air Quality Profile 2010). These two kinds of pollutants are detrimental to both human health and the environment.

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[3]http://www.iso.org/iso/about/iso_member.htm   Accessed on 2015/10/19.

[4]In recent years, ISO22000 food safety standards, ISO26000 social responsibility standards, ISO36000 risk management standards, and ISO50001 energy management systems are also introduced.

Figure-2 is inserted here

The pollution in Vietnam is on the verge of eruption and urgent solutions are sought to prevent the situation from getting worse. By using ISO14001—a voluntary environmental program as the benchmark, we would like to investigate what are the most important factors to affect firms' engagement in this program. Because such international standard, among many others, is proved to be effective in curbing the pollution behavior of firms (Arimura et al., 2008, 2011, 2014). And we expect to gain some inspiration from this practice, which would help to raise the overall firms' awareness of environmental protection in Vietnam.

3   Literature Review

By far there have been quite a few of studies to investigate the determinants of ISO14001, mainly from two perspectives: external and internal. External factors are usually derived from the demand side, such as the pressure from the stakeholder, customer and the government, or environmental preference. As known as signaling theory (Potoski and Prakash 2005), firms are joining voluntary environmental management programs to show their capability of dealing with environmental pollution. Representative empirical studies all indicate a positive relationship between foreign stakeholders and firms' earlier adoption of ISO14001. Chiristmann and Taylor (2001) with Chinese firm data, Wu et al. (2007) with Taiwanese manufacturing firm data, Arimura et al. (2008) and Nishitani (2009) with Japanese firm data all verify this finding. On the other hand, in terms of environmental preference, Nishitani (2010) uses a sample of 155 countries over eight years to show that customers in environmentally conscious markets are more likely to promote suppliers to adopt ISO14001.

Internal factors refer to firms' internal competence that can also promote firms' engagement in environmental protection. Arimura et al. (2008, 2011), Nakamura et al. (2001), Welch et al. (2002) reach a unanimous conclusion that larger firms, having quality management system and wider market scope of the industry where the firm locates are all important determinants that are associated with firms' capability. In the meantime foreign ownership is found to have a positive connection with energy efficiency (Eskeland and Harrison, 2003; He, 2006; Wang and Jin, 2002). This is interpreted by the advanced waste-processing technology adopted by foreign firms and their higher awareness to achieve corporate social responsibilities (Lyon and Maxwell, 2008). Recent studies such as Tambunlertchai et al. (2013) and Arimura et al. (2014) use Thai and Malaysian firm data respectively to show that foreign direct investment (foreign-owned firm or not) is positively related with firms' adoption of ISO14001. Similar result is achieved (Prakash and Potoski, 2006) in the macro level verification. On the other hand, capital-intensive industries are relatively pollution-intensive,

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thus firms in such industries are faced with more scrutiny from the customers and local government (Mani and Wheeler 1997; Gallagher 1999). Acquiring ISO14001 might help signal pollution-intensive firms' environmental capability and maintain their company image especially for capital-intensive firms.

However, to our best knowledge, few studies have attempted to elaborate on the real source of incentive for firms to rush for this standard in spite of its high cost. Levinson (2009) uses data in USA to show that most of firms' improvement in environmental protection activities comes with technology progress. While Copeland and Taylor (2003) verify that firms with higher technology tend to engage in more environment-friendly activities. Evidence seems to point to the direction that the difference of technology (or firm's productivity) is the key to variation in firms' behaviors. Taking advantage of the voluntary nature of ISO14001 adoption, we want to make clear what is behind the scene.

First in its kind, this paper is positioned as the one to study the real determinants of firms' strategic decision to participate in the voluntary environmental program. We will start with an analytical general equilibrium model which can lead to our estimable predictions.

4 Theoretical Model

4.1 General setting

In this section we outline a simple model of firms that produce differentiated goods and are faced with the choice of adopting ISO14001 while realizing the costly nature of this environmental standard. The basic settings are in analogous to the standard models in the literature of international trade, such as Melitz (2003), Bernard et al. (2007), Bernard et al. (2010,2011) (BRS hereafter), but differs in that firms have the new alternatives: apply or not apply for ISO14001. In contrast to the single-factor endowment setting in these studies, we assume there are two kinds of inputs used for production to rationalize our empirical prediction. Since our purpose is to introduce a simple and practical model that can lead to the data analysis, we try to simplify several assumptions. For example, we ignore the product heterogeneity and firms' trade status, since such information is not available in the actual dataset. Our model can be extended to the open economy case if trade information is to be included.

4.2 Endowments and Preference

Consumers with identical preferences try to maximize their utility by consumption over a continuum of differentiated products $i \in [0,1]$:

$$U = [\int_0^1 (C_i)^\rho di]^{\frac{1}{\rho}}, 0 < \rho < 1 \tag{1}$$

where $\sigma = 1/(1-\rho)$ is the constant elasticity of substitution (CES) across products.

In accordance with the domestic-export decision-making literature that emphasizes firms' heterogeneity in ability, we assume that firms differ in their productivity. In a monopolistic competitive market with free entry and exit, a firm draws its productivity φ randomly from a pareto distribution g(φ) upon paying the fixed cost (sunk) f_e to start production regardless of its ownership (foreign or domestic). For simplicity, we think of φ as firm-specific and constant across industries. Meanwhile a firm has the right to acquire the environmental standard ISO14001 by paying a larger cost which is proportionate to its total production cost, i.e. it is the linear combination of the fixed consulting cost f_x which includes the consulting fee and application fee, and the unit cost of the input. We can also regard the extra expense as the preparation fee used on additional personnel and capital to apply for the standard. To cover the extra expenditure, ready-to-adopt firms have the incentive to raise the price of the product. And since ISO14001-adopting firms spend more efforts on improving the "corporate image" of the products, they are justified to set the new price as p_x^* (where $p_x^* = \tau \cdot p_x$, p_x is the price of the same product before the firm with same productivity applies for ISO14001)[5]. We model the extra cost in such a manner that it can be comparable to the iceberg transportation cost used in international trade. Thus, if the productivity draw φ_x is large enough so that the firm has enough capacity to cover the extra cost used for ISO14001 acquirement and still make profit, the firm will have more incentive to adopt ISO14001 actively.

To take into account capital intensity, we need to deviate from the existing literature that focuses on the labor input only. Firms use two kinds of factors for manufacturing: labor and capital inputs. Following BRS, we assume that their supply is inelastic. The unit price for each factor input are w and r, whereas w stands for wage rate and r represents rental rate. Based on the modeling method used in Ma et al. (2014), we assume the total cost of the firm is:

$$TC_e = [f_e + \frac{q_e}{\varphi_e}]w^{1-s}r^s \tag{2}$$

For simplicity, we omit the superscript for the firm. We choose w as the numeraire ($w=1$). s indicates the capital intensity and we will consider two cases. In the first case, we do not

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impose any assumption on s and regard it as exogeneous. The second case is that we assume s is increasing in a firm's productivity. Since $\varphi_x > \varphi_e$, $s(\varphi_x) > s(\varphi_e)$ and the inequality still holds in equilibrium. We will discuss the scenario in the first case and come back to the second one. The profits for a firm to produce without and with ISO14001 respectively are:

$$\pi_e = p_e q_e - r^s (f_e + \frac{q_e}{\varphi_e}) \tag{3}$$

$$\pi_x = p_x q_x - r^s (f_x + \frac{q_x}{\varphi_x}) \tag{4}$$

Firm profit maximization helps us derive the optimal price setting in the status before and after acquiring ISO14001: $p_e = \frac{r^s}{\rho \varphi_e}$ and $p_x = \frac{\tau r^s}{\rho \varphi_x}$. Thus the cutoff productivity π_e^* (before acquiring ISO14001) above which the firm keeps producing, is determined by the zero-profit condition:

$$\pi_e^* = (\frac{r^s}{\rho \varphi_e^*})^{1-\sigma} P^{\sigma-1} \frac{R}{\sigma} - r^s f_e = 0 \tag{5}$$

where R is the total expenditure used for production and P is the aggregated price index of p_e. In the same way, we can derive the cutoff productivity π_x^* above which the firm chooses to adopt ISO14001 and continues producing:

$$\pi_x^* = \frac{r^s}{\varphi_x^*} (\frac{\tau}{\rho} - 1) R (\frac{\tau r^s}{\rho \varphi_x^*})^{-\sigma} P^{\sigma-1} - r^s f_x = 0 \tag{6}$$

4.3 Equilibrium conditions

In equilibrium, we can derive the cutoff value φ_e^* and φ_x^*, and the relationship between the two can be expressed as:

$$\varphi_x^* = \Lambda \varphi_e^*, \Lambda = \rho \cdot (\frac{f_x}{\sigma f_e (\frac{\tau}{\rho} - 1)(\frac{\tau}{\rho})^{-\sigma}})^{\frac{1}{\sigma-1}} \tag{7}$$

Apart from the zero-profit condition, the free entry condition should also be cleared. In other words,

$$f_e = [1 - G(\varphi_e^*)] \cdot \frac{\bar{\pi}_e + \bar{\pi}_x}{\delta} = 0 \tag{8}$$

where $G(\varphi)$ is the cumulative distribution function of $g(\varphi)$, and δ is the surviving rate. For the convenience of calculation, we assume that it takes a specific form such that $G(\varphi) = 1 - (\frac{\varphi_0}{\varphi})^k$, and $k > 1$. This is a standard function form of Pareto Distribution. $\bar{\pi}_e$ and $\bar{\pi}_x$ each stands for the expected average profit of a firm conditional on the status before and after adopting ISO14001. Because of law of large number, $\bar{\pi}_e$ and $\bar{\pi}_x$ can be represented as the

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function of φ_e^* and φ_x^* respectively[6]. Thus we can solve two unknowns with two Equations (7) and (8), and the difference is:

$$\bar{\pi}_x - \bar{\pi}_e = r^s[F(\varphi_x^*) - F(\varphi_e^*)] \tag{9}$$

where $F(\cdot)$ is the expected average profit excluding the factor of r^s in equilibrium. From the assumed function form of Equations (7) and (8), we can derive $F(\cdot)$ as an monotonically increasing function in $\varphi_i^*, i \in \{e, x\}$, because $\sigma - 1 > 0$. For a firm to apply for ISO14001 given the higher fixed cost, it is reasonable to expect that $\bar{\pi}_x > \bar{\pi}_e$, thus $F(\varphi_x^*) > F(\varphi_e^*)$. Together with the increasing nature of $F(\cdot)$, we can conclude that $\varphi_x^* > \varphi_e^*$. In other words, it is the difference in the expected equilibrium productivity under different status (non-adopted and adopted) that leads to firms' incentive to acquire the standard[7].

On the other hand, when the impact of productivity gap is excluded and ceteris paribus, the difference between $\bar{\pi}_x$ and $\bar{\pi}_e$ solely depends on r^s. Since we have defined w as 1 and capital input is basically more costly than labor input, we can assume that $r > 1$. As s increases, the expected profit gain after the adoption of ISO14001 will be enlarged, which gives the firm more incentive to apply for this standard. Based on the above arguments, we give the following proposition, which will be verified in the empirical estimation section.

Proposition 1: In a closed economy, holding other characteristics unchanged, higher productivity will increase a firm's willingness to adopted ISO14001. In the meantime, the more a firm is capital intensive, the more likely it is to adopt ISO14001[8].

4.4   Other control variables

Although not the key focus of this paper, we would like to discuss in brief how to model the other factors that might affect its decision to adopt ISO14001. We have mentioned in the earlier section that foreign-owned firms care more about their corporation social responsibility because the effort towards environmental protection will in fact affect the company image. Empirical evidence can be found in Prakash and Potoski (2011)[9]. In the meantime, foreign-owned firms are faced with more scrutiny from the foreign shareholders who have higher preference of "green" products (Bui and Kapon 2012). Therefore, the

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[6]See Appendix A-1 for detailed derivation.

[7]See Appendix A-2 for details

[8]As for the case when s is endogenously determined by each value of φ, it does not change our qualitative prediction. See Appendix A-1 for detailed discussion.

[9]Though their practice is from the macro perspective by exploring FDI stock's impact on the number of ISO14001 adoption in developing countries.

more foreign capital a firm has, the more cost it is willing to spend on environment-friendly activities including ISO14001 adoption. Apart from that, the size of the firm and the waste management department might also matter.

In previous section we have assumed that τ is exogenous. Suppose τ in fact consists of the potential determinants outlines above, and an unobserved term. From Equation (7) and derivation in Appendix A-3, we know that:

$$\varphi_x^* = \varphi_e^* \frac{r^{s(\varphi_e^*)}}{r^{s(\varphi_x^*)}} \cdot \rho \cdot \big(\frac{f_x}{\sigma f_e(\frac{\tau}{\rho}-1)(\frac{\tau}{\rho})^{-\sigma}}\big)^{\frac{1}{\sigma-1}}$$

Using some algebra and $\frac{\varphi_e^*}{\varphi_x^*}$ can be approximately expressed as:

$$\frac{\varphi_e^*}{\varphi_x^*} = r^{s(\varphi_x^*)-s(\varphi_e^*)} \cdot \kappa \cdot \tau(FDI\ share, firm\ size, waste\ management, unobserved)$$

where $\kappa = F(\rho, \sigma, f_e, f_x)$ and is constant. Since the probability of adopting ISO14001 is $(\frac{\varphi_e^*}{\varphi_x^*})^k = (r^{s(\varphi_x^*)-s(\varphi_e^*)} \cdot \kappa \cdot \tau)^k$, we take logarithm on both sides and come up with the expression which leads to our emipirical estimation:

$$ln\frac{\varphi_e^*}{\varphi_x^*} = ln\kappa + \beta_1 \cdot lnr^{s(\varphi_x^*)-s(\varphi_e^*)} + \beta_2 \cdot ln(FDI) + \beta_3 \cdot ln(firm\ size) + \beta_4 \cdot ln(waste\ management) + \epsilon$$
(10)

where the last term is the unobserved firm characteristics that might affect a firm's decision of ISO14001 adoption. In the next section, we will use matched data from Vietnam to estimate Equation (10). β_1 and β_2 are of our research interest. β_1 is expected to have positive sign, and the signs of β_2-β_4 are to be determined via empirical tool.

5   Estimation Strategy and Data

5.1   Data

This paper uses a panel dataset, constructed from the Vietnam Enterprise Survey at firm level. The data was collected by the General Statistics Office of Vietnam for all sectors and industries, as on March 1st annually. It covers all 22 manufacturing sectors out of the total 42. Since most ISO14001 adopters are concentrated in manufacturing industries (81%), we will limit our analysis to manufacturing firms only. Company characteristics such as ownership, labor, capital stock, turnover, assets, FDI share, average wage rate, intermediate materials are also available. Apart from the above, GSO has taken a census of all multinational

enterprises (MNEs), which are defined firms that have foreign capital, regardless of the share. The advantage is that investment behavior of these foreign capitalized firms can be captured over time. Census is also taken for firms with more than 10 employees. Each firm has an exclusive enterprise code. We use it together with province code to identify the firms.

Another uniqueness of this dataset is that it collects information on firms' engagement in environmental protection, including the cost spent on environmental protection, whether the firm carries out environmental management system, whether it follows the clean manufacturing process, etc. And above all, whether the firm has ISO14001 certification is recorded. Since it is relatively objective criteria that is free of measurement error, we use it to create our ISO adoption dummy. Unfortunately, the ISO information is only accessible from 2007 to 2009, we have to limit our analysis to this time period. Finally, the detailed data on waste discharge categorized by form (air, liquid, solid) is also available.

There are also some limitations concerning the data, for instance, the incomplete information about export and import, missing data for materials and other variables, inconformity of units among different years, etc. As a result, we have to deal with an unbalanced panel data here. We remove the missing observations, and delete outliers. After these arrangements, the total number of observations for estimation is 28274 over three years.

Table 1 is inserted here

In practice, we will replace capital intensity and foreign capital share with their one period lag respectively to alleviate reverse causality concern. We will change the specifications to see how robust it is.

5.2   Baseline estimation and results

The dependent variable is a binary choice. Thus in the baseline estimation we apply the random-effect panel Logit or Probit, and model a firm's decision making of ISO14001 adoption as the conditional mean of firms' observed idiosyncratic characteristics. In practice, to alleviate the reverse causality concern, we replace the variables of interest with their one period lags.

In the first two columns of Table 2, we would like to verify the sole influence of a firm's productivity on its decision making, as predicted in the first part of Proposition 1. Since we don't have enough information on the intermediate goods, Levinsohn and Petrin style TFP can not be fully applied. As an alternative, we adopt the stochastic frontier method. See the details in Lovell and Kumbhakar (2000). We only include year dummy, industry dummy and

waste department dummy as control variable. In either specification, TFP is positive and strongly significant. Though the coefficient varies between models, the robustness provides sufficient evidence that it is one of the most important determinants for a firm to adopt ISO14001.

We show the results of estimating Equation (10) in Columns (3) and (4). While productivity maintains its significancy, *foreign capital share*, *total employment*, *waste department dummy* and *capital labor ratio*, are all statistically significant at the 1% level. The estimated coefficient of *foreign capital share* is positive, which means that firms with foreign capital actively adopt ISO14001. The positive sign of *total employment* indicates that the larger a firm is, the more likely it is to adopt ISO14001. One explanation might be that larger firms have more capacity to participate in such voluntary programs. In accordance with our theoretical prediction, *capital labor ratio* is positive, implying that capital-intensive firms have more incentive to adopt ISO14001.

Table 2 is inserted here

5.3   Robustness check and further issues

Robustness check

Though reverse causality is considered in the baseline estimation, another source of endogeneity might arise: the sample selection. It is natural to assume that firms with higher productivity (or capital intensity) might select to adopt ISO14001 to gain further profits, and the selection bias will affect our estimation of the coefficients of the variables. To alleviate the bias, we adopt the "ivprobit" model. The instrument needs to be correlated with productivity or capital intensity, but does not affect the decision of ISO14001 adoption. In practice, we use the number of workers whose education levels are equal to or above college, as the instrumental variable (IV). This measurement is quite likely to affect a firm's productivity level, but less possible to determine the ISO14001 acquirement.

We make additional efforts to test the robustness of other control variables as well. Apart from applying *waste department dummy* as the determinant of ISO14001 adoption, we use *total cost environmental* and *environmental system* as proxies alternatively. Furthermore, to disentangle the potential impact that the existing pollution level might have on firms' willingness to apply, we include the amount of liquid and solid waste discharge as additional control variables. Such practice does not change the qualitative results concerning the roles that capital intensity and foreign capital share of a firm play. Due to space constraint, we

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do not present all the estimation results but they are available upon request.

Difference across industries

Given the fact that most firms adopting ISO14001 are in the manufacturing industry, we have the reason to believe that the incentive for the firms from other industries to adopt ISO14001 can be different. We are thus motivated to confirm how the impact of the determinants of ISO14001 adoption differs across industries. Accordingly, we further divide samples by industry and conduct the estimation as in Equation (10). The upper panel of Table 3 shows the results when we use the samples in food industry only and the lower panel is for the manufacturing industry.

Productivity is positive and significant for both industries. However, the magnitude of its influence in the manufacturing industry is larger than that in the food industry, showing that the technology is crucial for manufacturing firms to care more about their engagement in environmental activities. Meanwhile, when we limit the samples to food industry, *foreign capital share* lost its significance. This indicates that foreign firms in those industries other than manufacturing might not value the corporate social responsibility as much as those in the manufacturing industry. It is also likely that foreign-owned firms from manufacturing-excluded industries in Vietnam do not respond actively to the shareholders' expectation of "green products". On the other hand, *capital labor ratio* is still significant, but its marginal effect is reduced to half of that as in the manufacturing industry. The interpretation is that since in manufacturing sectors, firms produce products that heavily rely on usage of labor, machines and tools, the costs and benefits of applying more eco-friendly inputs will be weighed in a more serious way by each firm. Consequently capital intensity plays a relatively more important role in firms' decision of ISO14001 adoption. The post-estimation likelihood-ratio test ensures the appropriateness of the model (rejection of the null).

Table 3 is inserted here

6   Conclusion

We use the firm level survey data from 2007-2009 in Vietnam to investigate the determinants of the adoption of ISO14001, a voluntary environmental standard. We try to uncover the mechanism of how firms form the decision of adoption. Theoretically, by employing a general equilibrium model, we show that more productive and capital intensive firms will

systematically have higher incentive to adopt because of the larger expected benefits, despite a higher fixed and variable cost. In the empirical verification, a random-effects Probit (Logit) model is applied to confirm our prediction. Some robustness checks are conducted and the qualitative results remain unchanged.

Furthermore, we try to verify the differential influence that the above determinants might have on ISO14001 adoption of firms in different industries. Both productivity and capital intensity have higher decisive impact on the ISO14001 adoption of firms from non-food manufacturing industry that those from other industries. In the meantime, foreign capital share shows its significancy particularly in manufacturing industries, which to some extent offers the evidence to refute the critics of "pollution haven hypothesis" due to foreign firms' active investment activities.

The above findings can lead to some policy implications that are especially critical to Vietnam because the country is faced with serious pollution problem. Due to the notion that ISO14001-adopting firms have generally higher awareness of environmental protection, it is urgent that Vietnamese government explore more efficient ways to promote all firms' engagement in voluntary environmental program (not limited to ISO14001). Technology progress poses as a solution (which reduces firms' abatement cost), but it needs be supplemented by such policies as subsidies and tax exemption provided to domestic firms that show capability to engage in environmental protection.

Last but not least, our paper can be improved in many ways. For example, it would be more practical to take into account the influence of international trade, because a firm's effort towards adoption environmental standard is also associated with its export destination and how much it trades. Further extension can take into account industrial and regional heterogeneity as well.

7 Appendix

A-1: Derive a firm's average profit as a function of its equilibrium productivity level φ^*.

The productivity distributions for non ISO14001-adopted and adopted firms are: $\mu_e(\varphi) = \frac{g(\varphi)}{1-G(\varphi_e^*)}$ if $\varphi \geq \varphi_e^*$ and $\mu_x(\varphi) = \frac{g(\varphi)}{1-G(\varphi_x^*)}$ if $\varphi \geq \varphi_x^*$. And the average profits of a firm before and after adopting ISO14001 can be expressed as follows:

$$\bar{\pi}_e = \int_{\varphi_e^*}^{\infty} \frac{\pi_e(\varphi)g(\varphi)}{1-G(\varphi_e^*)} \, \mathrm{d}\varphi \tag{11}$$

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$$\bar{\pi}_x = \int_{\varphi_x^*}^{\infty} \frac{\pi_x(\varphi)g(\varphi)}{1 - G(\varphi_x^*)} \, \mathrm{d}\varphi \tag{12}$$

where we can rewrite Equation (11) as:

$$\int_{\varphi_e^*}^{\infty} \frac{[(\rho\varphi_e P)^{\sigma-1}(r^s)^{-\sigma}R - r^s f_e]g(\varphi)}{1 - G(\varphi_e^*)} \, \mathrm{d}\varphi \tag{13}$$

Let ϕ be the firm's revenue, i.e. $p * q$. Following BRS (2010), we have

$$\frac{\phi(\varphi'')}{\phi(\varphi')} = (\frac{\varphi''}{\varphi'})^{\sigma-1}$$

$$\Rightarrow \frac{\phi_e(\varphi_x^*)}{\phi_e(\varphi_e^*)} = (\frac{\varphi_x^*}{\varphi_e^*})^{\sigma-1} \tag{14}$$

Substituting Equation (14) into (13), we get:

$$\bar{\pi}_e = \int_{\varphi_e^*}^{\infty} \frac{[(\frac{\varphi}{\varphi_e^*})^{\sigma-1} r^s f_e - r^s f_e]g(\varphi)}{1 - G(\varphi_e^*)} \, \mathrm{d}\varphi$$

The zero profit condition indicates that $r^s f_e$ is equal to $\phi(\varphi_e^*)$, thus $\bar{\pi}_e$ can also be represented by φ_e^*'s function. In the same way, $\bar{\pi}_x$ can be written as a function of φ_x^* as well.

A-2: Numerical example to show a firm's incentive to adopt ISO14001.

We focus on the general profit conditions: Equations (5) and (6). After rearranging, the first terms on the right hand side of both equations become the following:

$$\frac{1}{\rho\sigma} \cdot (\varphi_e^*)^{\sigma-1}(r^s)^{1-\sigma}RP^{\sigma-1} \tag{15}$$

$$(\frac{\tau}{\rho} - 1)\tau^{-\sigma} \cdot (\varphi_x^*)^{\sigma-1}(r^s)^{1-\sigma}RP^{\sigma-1} \tag{16}$$

For simplicity, we leave out the common factor and only have to compare $\frac{1}{\rho\sigma} \cdot (\varphi_e^*)^{\sigma-1}$ with $(\frac{\tau}{\rho} - 1)\tau^{-\sigma}$. Following Balistreri et al. (2011), we let $\sigma = 3.8$, then $\rho = .74$. We further assume that $\tau < 1.1$, since In reality, it is hard to imagine that firms are willing to pay an extra 10% (or larger) of its total operation cost to acquire the voluntary environmental standard. Though a larger τ over 1.1 will not change our prediction.

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Substituting the values into the above expressions and we get $\frac{1}{\rho\sigma} \cdot (\varphi_e^*)^{\sigma-1} \approx .356$ and $(\frac{\tau}{\rho}-1)\tau^{-\sigma} \approx .338$. Because the profit function is increasing in φ^*, to satisfy Equation (5) and (6), a larger φ_x^* will be necessary so that the value of the term in Equation (16) surpasses that of the term in Equation (15)[10]. This lends support to the notion that without the growth of productivity, a firm will have little chance to start considering the adoption of ISO14001.

A-3: Discussion on the case when capital intensity s is also the function of the firm's productivity φ.

As shown by Yeaple (2005), Harrigan and Reshef (2012), Verhoogen (2008), productive firms are usually more capital-intensive. Thus it is natural to make the assumption that $\frac{\partial s}{\partial \varphi} > 0$. Since $r > 1$, r^s is therefore a monotonically increasing function of a firm's idiosyncratic productivity. Accordingly, Equation (7) becomes:

$$\varphi_x^* = \frac{r^{s(\varphi_e^*)}}{r^{s(\varphi_x^*)}} \cdot \Lambda \varphi_e^*, \Lambda = \rho \cdot \left(\frac{f_x}{\sigma f_e(\frac{\tau}{\rho}-1)(\frac{\tau}{\rho})^{-\sigma}}\right)^{\frac{1}{\sigma-1}}$$

From Equation (9), we know that $\bar{\pi}_x - \bar{\pi}_e = r^s[F(\varphi_x^*) - F(\varphi_e^*)] > 0$, and since $r^{s(\varphi_x^*)} > r^{s(\varphi_e^*)}$, we will have $r^{s(\varphi_x^*)}F(\varphi_x^*) > r^{s(\varphi_e^*)}F(\varphi_e^*)$ as long as $\varphi_x^* > \varphi_e^*$. Another way to confirm firms' decision-making is to calculate the probability of ISO14001 adoption. Similar to the probability of export in Melitz (2003), a firm's willingness to adopt ISO14001 P_{ISO} can be expressed as: $\frac{1-G(\varphi_x^*)}{1-G(\varphi_e^*)}$, where φ_x^* and φ_e^* are cutoff values for ISO14001 adoption and initiating production. Given the specific function form of G, we have the following expression:

$$P_{ISO} = \left(\frac{\varphi_e^*}{\varphi_x^*}\right)^k = \left(\frac{r^{s(\varphi_x^*)-s(\varphi_e^*)}}{\Lambda}\right)^k, k > 1$$

Because Λ is assumed to be constant, as s increases, P_{ISO} will be enlarged as well, indicating that the capital intensity level determines a firm' propensity to adopt ISO14001.

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[10]When τ approaches 1 from above, $(\frac{\tau}{\rho} - 1)\tau^{-\sigma}$ will be enlarged to get close to $\frac{1}{\rho\sigma}$. In the special case when $\tau = 1$, which indicates that $f_x = f_e$, Equations (5) and (6) will converge.

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Figure-1 The difference in firms' TFP in Vietnam

Pre-TFP for ISO14001-adopted firms   Pre-TFP for non ISO14001-adopted firms
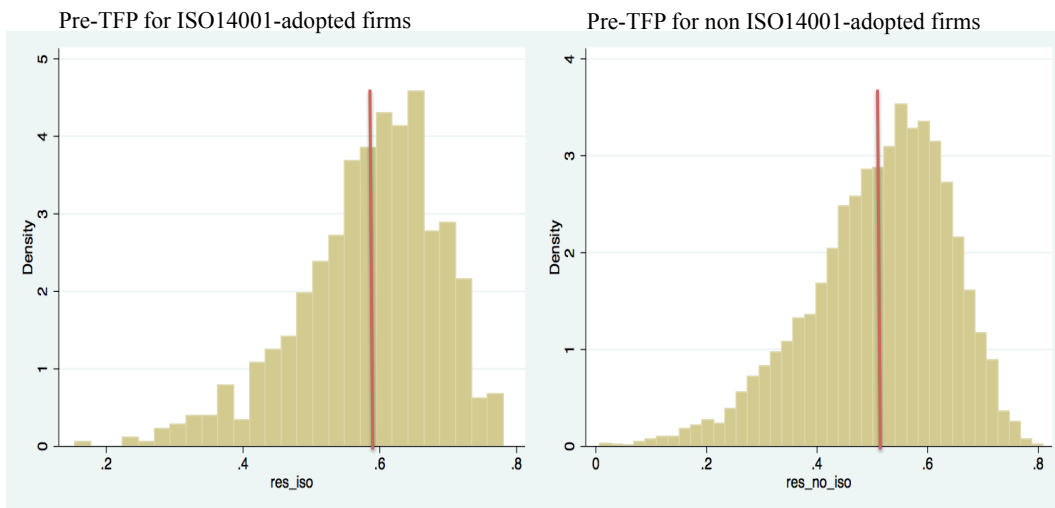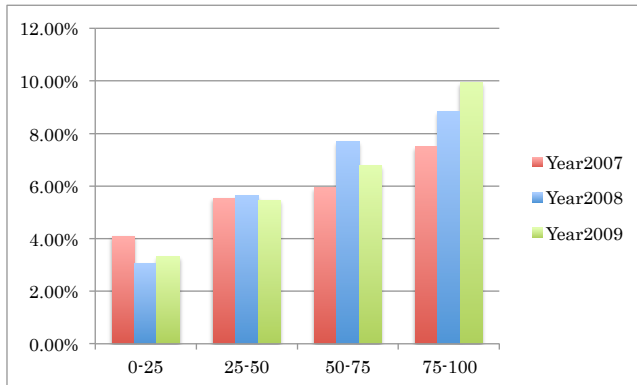

Source: Annual Enterprise Survey, GSO Vietnam

* TFP is calculated using Stochastic Frontier Method.

Figure-2   ISO14001 adoption rate by capital intensity
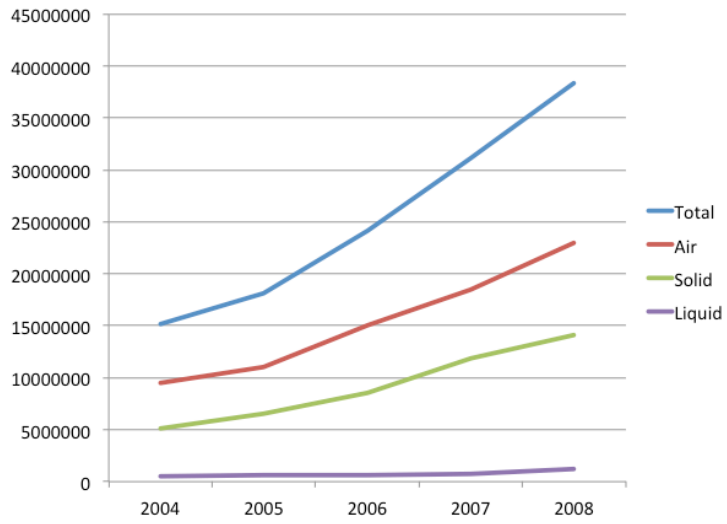
Year 2007-2009 in total
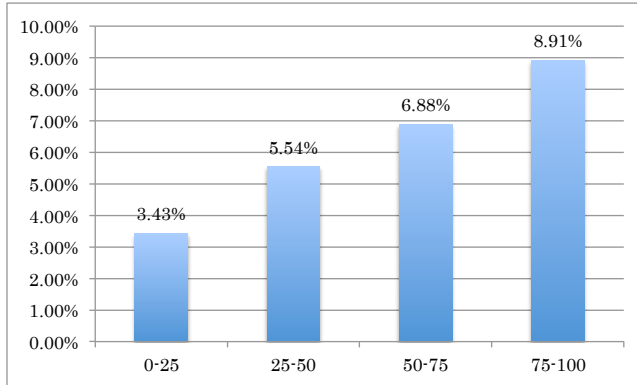
Each year

Source: Annual Enterprise Survey, GSO Vietnam

Figure-3　Pollution Level in Vietnam (tons)

Source: GSO, Vietnam and World Bank IPPS

Table 1 Statistical Summary

Variable	N	Mean	S.D.	Min	Max	Definition
liquid	28274	19.95423	26.67161	0	100	treated liquid waste/total liquid waste (%)
solid	28274	23.00456	24.83821	0	99.9001	treated solid waste/total solid waste (%)
total_employment	28274	236.2577	873.1979	1	61297	number of employees at the beginning of the year (Person)
ISO14001	28274	0.058216	0.2341556	0	1	whether the firm has ISO14001
FDI_capital_share	28274	17.57954	37.33238	0	100	foreign capital/total capital (%)
capital_labor_ratio	28274	167.0986	1096.249	0	98623.28	the ratio of capital/total employment
food_manufacturing dummy	28274	0.1333734	0.3399839	0	1	if the firm is in the food-manufacturing industry, the dummy takes 1
manufacturing dummy	28274	0.5108934	0.4998902	0	1	if the firm is in the food-excluded-manufacturing industry, the dummy takes 1
totalcost_environment	28274	1199.974	120352.4	0	20100000	total costs for environmental protection (Mill. Dongs)
waste_department dummy	28255	0.2725535	0.4452809	0	1	whether the firm has environmental protection department
environmental_system	28268	0.2772747	0.4476612	0	1	whether the firm carries out environmental management system
environmental_standard	28265	0.2619848	0.4397222	0	1	whether the firm meets requirements of environmental standard

Source: General Statistics Office, Vietnam

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Table 2   Baseline Estimation Results

	(1)	(2)	(3)	(4)
Model	Logit	Probit	Logit	Probit
Dependent Variable	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy
Lag (TFP)	7.450***	4.094***	6.102***	3.338***
	(0.892)	(0.493)	(0.875)	(0.485)
Lag (foreign capital share)			0.00793***	0.00438***
			(0.00201)	(0.00112)
Total number of workers			0.000467***	0.000262***
			(6.96e-05)	(3.81e-05)
Lag (capital labor ratio)			0.000280***	0.000155***
			(9.25e-05)	(5.00e-05)
Manufacturing industry dummy	0.786***	0.430***	0.530**	0.286**
	(0.230)	(0.128)	(0.241)	(0.133)
Food industry dummy	0.243	0.134	0.299	0.162
	(0.283)	(0.157)	(0.287)	(0.158)
Waste department dummy	2.810***	1.534***	2.556***	1.388***
	(0.248)	(0.117)	(0.236)	(0.115)
Observations	8,283	8,283	8,283	8,283
Number of id	5,961	5,961	5,961	5,961

Note: Random-effects Logit and Probit models are applied.

Standard errors in parentheses. Year dummies are included.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3 Industry Comparison

	(1)	(2)	(3)	(4)
Model	Logit	Probit	Logit	Probit
Dependent Variable	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy
Food industry				
Lag (TFP)	5.652***	3.041***	4.785***	2.557***
	(1.124)	(0.617)	(1.125)	(0.612)
Lag (foreign capital share)			0.00200	0.00114
			(0.00381)	(0.00208)
Total number of workers			0.000319***	0.000180***
			(0.000117)	(6.47e-05)
Lag (capital labor ratio)			0.000199**	0.000109**
			(9.95e-05)	(5.28e-05)
Waste department dummy	2.267***	1.212***	2.102***	1.118***
	(0.299)	(0.159)	(0.300)	(0.159)
Observations	3,166	3,166	3,166	3,166
Number of id	2,333	2,333	2,333	2,333
Manufacturing industry				
Lag (TFP)	8.918***	4.943***	7.382***	4.089***
	(1.336)	(0.727)	(1.295)	(0.722)
Lag (foreign capital share)			0.00915***	0.00508***
			(0.00252)	(0.00140)
Total number of workers			0.000529***	0.000297***
			(9.10e-05)	(4.97e-05)
Lag (capital labor ratio)			0.000381**	0.000215**
			(0.000157)	(8.57e-05)
Waste department dummy	3.147***	1.745***	2.886***	1.594***
	(0.381)	(0.163)	(0.364)	(0.166)
Observations	5,028	5,028	5,028	5,028
Number of id	3,582	3,582	3,582	3,582

Note: Random-effects Logit and Probit models are applied. Standard errors in parentheses. Year dummies are included.   *** $p<0.01$, ** $p<0.05$, * $p<0.1$